# Bird Surveys of McKinley Bay and Hutchison Bay, Northwest Territories, 1981-1985

# BIRD SURVEYS OF McKINLEY BAY AND HUTCHISON BAY, NORTHWEST TERRITORIES, 1981-1985

by

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Prepared for:

CANADIAN WILDLIFE SERVICE

and

INDIAN AND NORTHERN AFFAIRS CANADA

March 1986

SUMMARY

A five-year monitoring study of waterbird abundance and distribution at McKinley Bay, Northwest Territories, was conducted from 1981 to 1985. The main objective was to gain baseline data on annual population fluctuations of moulting diving ducks, prior to extensive development of the bay. McKinley Bay has been identified as a preferred site for a medium draft harbour to support oil and gas production in the Beaufort Sea. The data obtained in this study will serve as a data base to assess the effect of future harbour development on the birds at McKinley Bay.

Aerial surveys were conducted annually at McKinley Bay in mid-summer. Since 1982, a nearby area, Hutchison Bay, was also surveyed as a control. This report gives the results of the aerial surveys conducted in 1985, as well as a summary of the data from all five years of the study. This is the final report on the pre-development phase of the study.

In 1985, aerial surveys were flown on August 4. Ice remained in both bays later in 1985 than in the previous years of the study, and during the 1985 survey, ice covered about one-third of each bay. The number of diving ducks at McKinley Bay on August 4, 1985, was estimated to be 6964 $\pm$ 1382 (standard error), while at Hutchison Bay, the estimated population was 10 169 $\pm$ 1120 diving ducks.

On average, during the five years of this study, over 12 000 diving ducks utilized McKinley Bay in early August each year, while over 13 000 diving ducks utilized Hutchison Bay. Oldsquaw and scoters were

by far the most common species of diving ducks observed at both bays, although there was some fluctuation in their numbers during the study. At McKinley Bay, numbers of scoters dropped significantly ($p < 0.10$) in 1985 compared to other years, while Oldsquaw numbers remained fairly constant. At Hutchison Bay, significantly higher densities of Oldsquaw were observed in 1984 than in any other year ($p < 0.05$).

At McKinley Bay, diving ducks tended to concentrate southeast of Atkinson Point and at the south end of the bay. Both Oldsquaw and scoters utilized the Atkinson Point area, although Oldsquaw were more common in this area than scoters. The concentrations of diving ducks at the south end of the bay were primarily scoters. Also, scoters were more frequently seen in large flocks of more than 50 birds than were Oldsquaw.

Possible reasons for observed variations in numbers and distribution of diving ducks in these bays are discusssed. As food availability is likely a significant factor affecting the ways that diving ducks utilize these bays, it is recommended that feeding studies be carried out within McKinley Bay.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the following people for their contribution to the study in 1985. H. Loney Dickson assisted with the aerial surveys and reviewed the manuscript; John Ward provided information regarding industrial activities in McKinley Bay; Sam Barry and Eric Woodsworth gave advice regarding the data analysis; Bert Poston and Tom Barry provided helpful comments on the manuscript; Susan Popowich drafted the figures; and Heather Breen typed the manuscript.

This study was jointly funded by: the Canadian Wildlife Service, Environment Canada; and the Office of Environment and Conservation, Northern Affairs Program, NWT Region, Indian and Northern Affairs Canada. Polar Continental Shelf of the Department of Energy, Mines and Resources provided logistical support.

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## 1.0 INTRODUCTION

McKinley Bay is a shallow protected bay on the north side of the Tuktoyaktuk Peninsula, Northwest Territories (NWT), in the eastern Beaufort Sea. Since 1979, it has been the site of a winter harbour and support base used by Dome Petroleum Limited for oil and gas exploration in the Beaufort Sea. Dredging in the bay began in September of 1979 with construction of an entrance channel and mooring basin in the northeast portion of the bay. Storm-driven ice shoved against the ships moored in this basin the following winter. Consequently, in 1980, another mooring basin was dredged in a more sheltered location to the southwest. An island to the north of the basin was created with the dredged spoils to further protect the moored ships from storms and ice movement. In 1981, the artificial island and the mooring basin were expanded, and docking facilities were constructed on the island. Major activity directed towards continuing the development of the harbour has not occurred since 1981. A summary of the industrial activities occurring in McKinley Bay in the 1984-85 season is given in Appendix D.

In the future, McKinley Bay may become a major year-round support base for Beaufort Sea oil and gas development (Dome Petroleum Ltd. et al. 1982). The Canadian Wildlife Service was concerned that these developments could adversely affect bird usage of the area, and that there was little quantitative data on which to assess the impacts of harbour development. Baseline information on numbers of birds using the area before extensive development, and on the natural annual fluctuations in bird numbers, was needed to allow the Canadian Wildlife

Service to detect impacts related to development. For this purpose, a bird-monitoring study involving aerial surveys with joint government and industry participation was initiated in 1981. Beginning in 1982, Hutchison Bay, a relatively undeveloped area on the Tuktoyaktuk Peninsula 45 km southwest of McKinley Bay, was also surveyed annually, as a control.

This report represents the final report of the pre-development phase of the study and includes data presented in several earlier reports (Scott-Brown et al. 1981; Cornish and Allen 1983; Cornish and Dickson 1984; Cornish and Dickson 1985), as well as the results from the 1985 surveys. Emphasis throughout the study was on documenting the number and distribution of moulting diving ducks, due to their abundance in McKinley Bay and their vulnerability to oil spills.

## 2.0 METHODS

### 2.1 Aerial Surveys

To allow comparisons between years of data on abundance and distribution of waterbirds, the same survey methods were used during all five years of the study. East-west transects were flown 2 km apart (Figs. 1 and 2). The surveys were carried out in a Cessna 185 with floats at an elevation of 30 m above ground level (agl) and at an average speed of 145 km/h. One observer on each side of the aircraft counted all birds seen within 180 m of that side, so that the total transect width was 360 m. When time permitted, "off transect" birds, more than 180 m from the plane, were also recorded, but were not

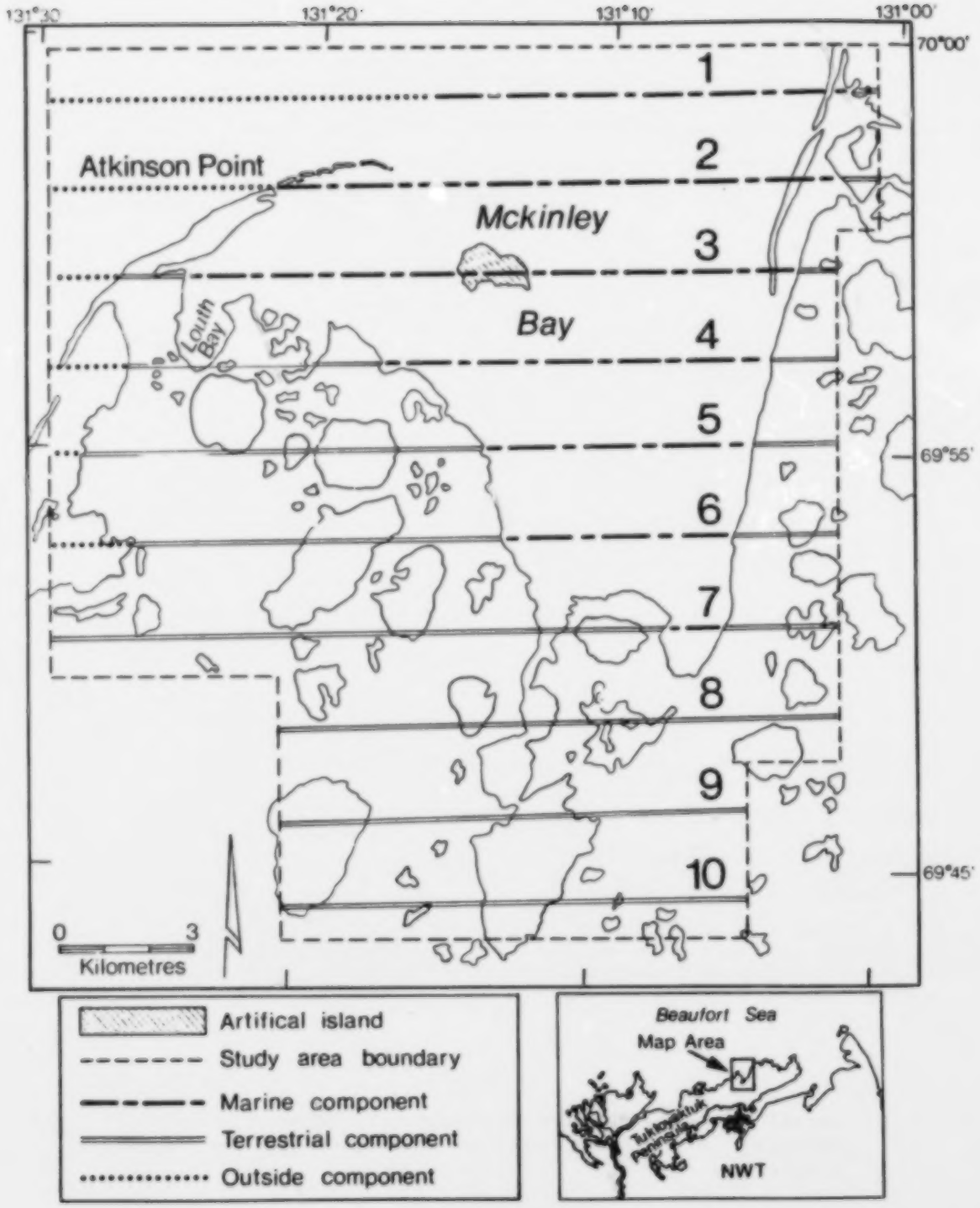


**Figure 1.** Aerial transects flown at McKinley Bay, August 4, 1985, showing the divisions of the study area into marine, terrestrial and outside components.

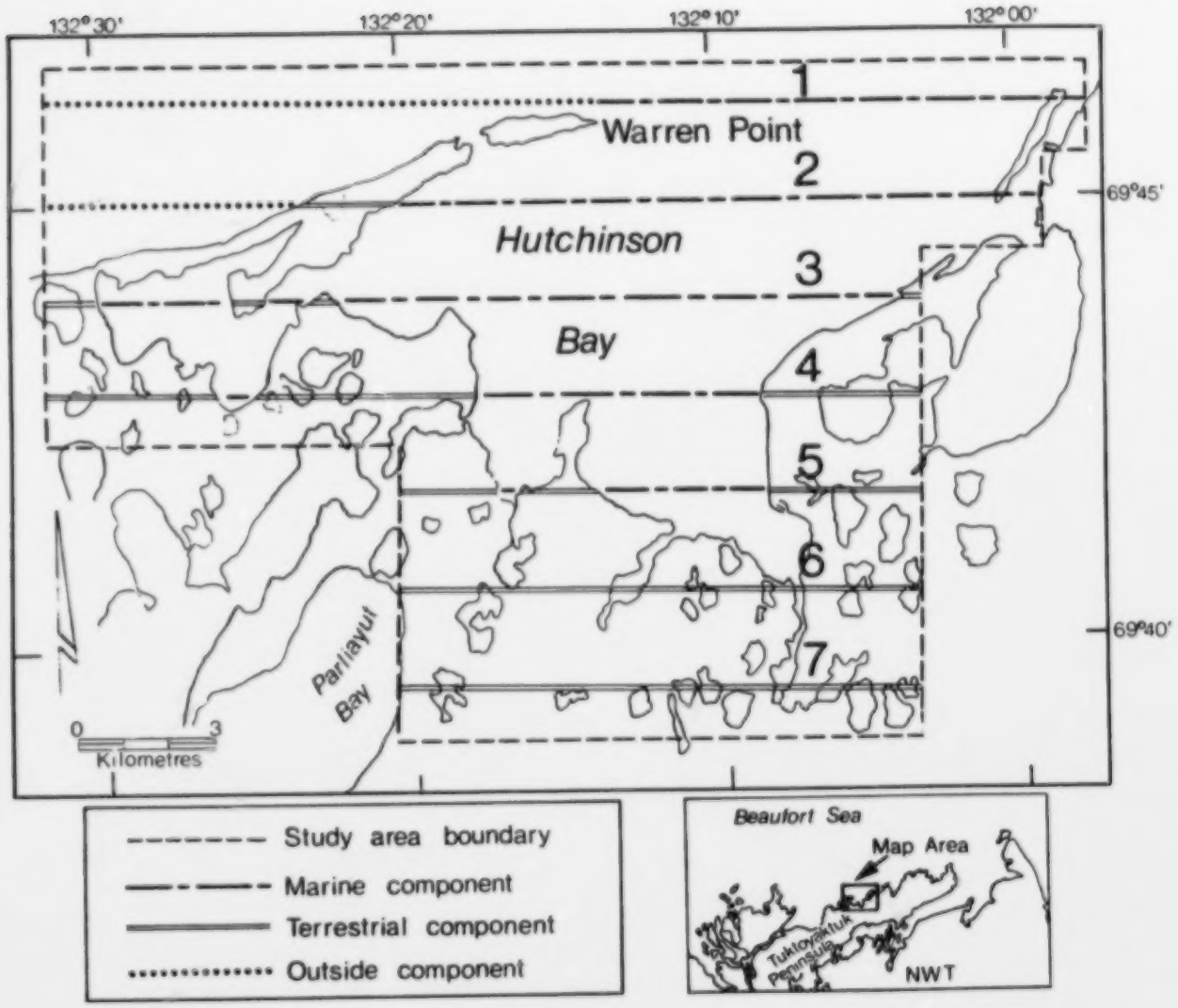


**Figure 2.** Aerial transects flown at Hutchison Bay, August 4, 1985, showing the divisions of the study area into marine, terrestrial and outside components.

included in calculations. Observations were dictated into tape recorders so that observers never had to look away from the transect. To reduce bias due to differences in observer skill, the same observers were used for all five years of the study, with the exception of one of the observers in 1981. All observers had current experience in aerial surveys.

In 1981 and 1982, the aerial surveys were flown at 10-day intervals to measure seasonal variations in bird abundance. Throughout July and August in 1982, additional surveys were conducted, by boat and on foot, in order to determine any relationship between the distribution of waterfowl and the tidal phase, time of day and weather. The techniques used for the boat surveys and the shoreline surveys on foot are summarized in an earlier report (Cornish and Allen 1983). In 1982, the first half of August was the peak period of moult for diving ducks in the bay. Also, it became apparent that good survey conditions (calm sea and light cloud) were imperative for accurate survey results. Therefore, each year for the remainder of the five-year study, starting at the beginning of August, surveys were conducted only on days when good survey conditions occurred. In 1985, only one aerial survey was flown, because weather conditions were poor in early August and a Cessna 185 was not always available.

The study area at McKinley Bay was divided into three components: a marine component inside McKinley Bay, a terrestrial component, and a section of marine habitat outside McKinley Bay called the outside component (Fig. 1). The marine component encompassed all saltwater

areas within McKinley Bay including exposed sandspits which were intermittently washed over by tides. The terrestrial component covered all land areas including inland lakes and the lagoon system at the south end of the bay. The area west of Atkinson Point, the small bay at the west end of transects 4 to 6, and the western half of transect 1 were considered the outside component. The areas of each component and the proportions surveyed are listed in Table 1. The total size of the study area was 305 $km^2$. The area of the marine section of McKinley Bay was 108.5 $km^2$ and the terrestrial section was 158.5 $km^2$.

Hutchison Bay was first surveyed in 1982. Aerial surveys were conducted at Hutchison Bay on the same day as McKinley Bay, using identical procedures. The study area at Hutchison Bay was divided into marine, terrestrial and outside components comparable to the McKinley Bay components (Fig. 2). Again, sandspits intermittently washed over by tides were considered marine. Other land areas and all inland lakes were part of the terrestrial component. The saltwater areas west of Warren Point and the area covered by the western half of transect 1 were considered outside of Hutchison Bay. Table 1 presents the areas of the components at Hutchison Bay and proportions surveyed.

The terms "diving ducks" and "divers", which are used throughout this report in tables and discussions, refer to ducks belonging to both Aythyinae and Merginae.

Table 1. Aerial survey coverage of designated components of the McKinley Bay and Hutchison Bay study areas.

| Component | McKinley Bay | | Hutchison Bay | |
|---|---|---|---|---|
| | Total area ($km^2$) | Area surveyed ($km^2$) | Total area ($km^2$) | Area surveyed ($km^2$) |
| Marine | 108.5 | 19.6 | 100.5 | 17.8 |
| Terrestrial | 158.5 | 28.3 | 91.0 | 16.3 |
| Outside | 38.0 | 6.9 | 31.5 | 5.8 |
| TOTAL | 305.0 | 54.8 | 223.0 | 39.9 |

## 2.2 Analysis of Data

With the systematic survey design presented above, the mean densities for each species were estimated by the standard ratio estimator. Population estimates were found through extrapolation, by multiplying the estimated mean density of birds by the total area of the study component (Table 1). Estimates of the standard errors of these variables were calculated using the method by Kingsley and Smith (1980). These equations are summarized below.

Let N = number of possible transects in the study area

n = number of transects sampled

f = n/N

$y_i$ = number of observations recorded on the $i$th transect

$x_i$ = area of the $i$th transect

Then:

(1) The standard ratio estimate $\hat{R}$ of the true mean density was given by:

$$\hat{R} = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} \bar{x}}$$

(2) The standard error of the mean density was estimated by the following:

Standard error = $\sqrt{s_1^2}$

$$s_1^2 = \frac{(1-f) \sum_{i=1}^{n-1} (d_i - d_{i+1})^2}{2 \cdot (n-1) \cdot n \cdot \bar{x}^2}$$

where $d = y_i - \hat{R}x_i$

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

(3) The standard error of the population estimate was found by multiplying $\sqrt{s_1^2}$ by the total area of the study component (Table 1).

To determine annual variation in counts, the data from all years of this study, from 1981 to 1985, were used. For each year from 1981 to 1984, the survey with the best weather and sea conditions was chosen for comparison with other years. In 1985, only one aerial survey was conducted.

The uneven distribution of divers in the bay frequently resulted in large standard errors when we used parametric statistics to determine annual variation in previous years of this study. Therefore, we chose the Kruskal-Wallis test (Conover 1980) to check the hypothesis that the observed diving duck densities from each year were identical, against the alternative that the observed densities in some years were higher than in other years. This non-parametric test follows a completely randomized experimental design, and utilizes ranks instead of counts to calculate the test statistic T. Densities on each transect were calculated for each year and the set of all data was ranked from smallest to largest. If the test resulted in rejection of the null hypothesis of no differences between years, the results from individual

years were compared using the procedure outlined in Conover (1980). It was apparent that, at McKinley Bay for all years, counts on transect 1, which was located on the offshore edge of the study area, were always low and consistently received the lowest ranks in the set of all McKinley Bay data. Because of this, the data from transect 1 at McKinley Bay were excluded from the Kruskal-Wallis analysis.

## 3.0 RESULTS

### 3.1 Survey Conditions in 1985

The aerial surveys at McKinley and Hutchison bays on August 4, 1985 were conducted between the hours of 1038 and 1330. During the surveys, there was 80-90% cover of altocumulus cloud. Wind speeds were visually estimated from the aircraft, and winds at both bays were light (less than 10 km/hr) and variable, although generally from the southeast. Sea conditions were nearly calm. The temperature during the surveys varied between 8° and 11°C and there was no precipitation. Weather conditions were considered excellent for surveying, with just enough cloud cover to prevent glare while allowing enough light for accurate species identification.

However, during the surveys at McKinley Bay and Hutchison Bay in 1985, ice covered about one-third of each bay (Figs. 3 and 4). The ice was mainly broken pack ice subject to movement by winds. In many areas of both bays, this brash ice was jammed together densely to form a solid mass with no more than 10% open water. Other areas of both bays were

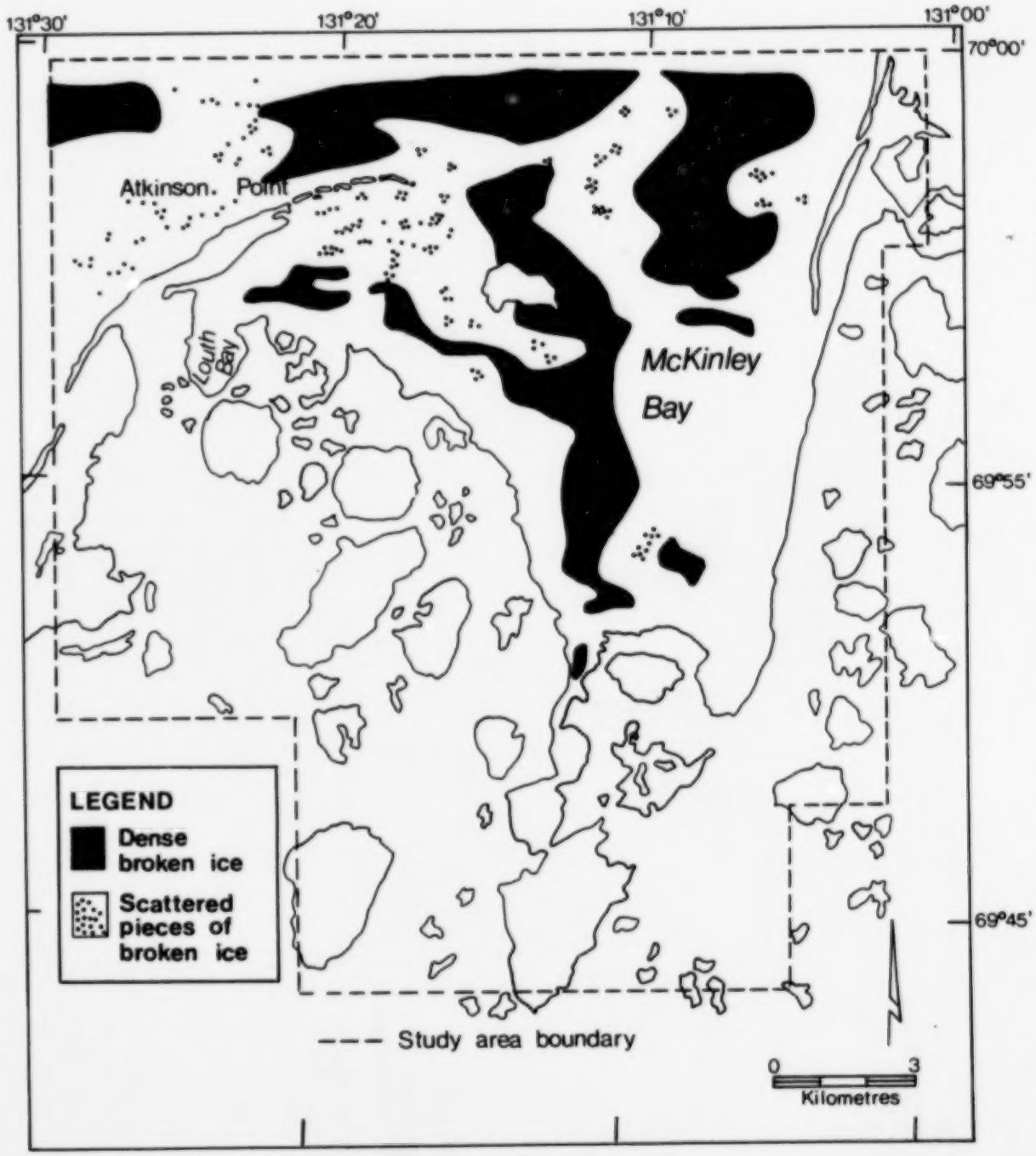


Figure 3. Ice conditions at McKinley Bay during the aerial survey on August 4, 1985.

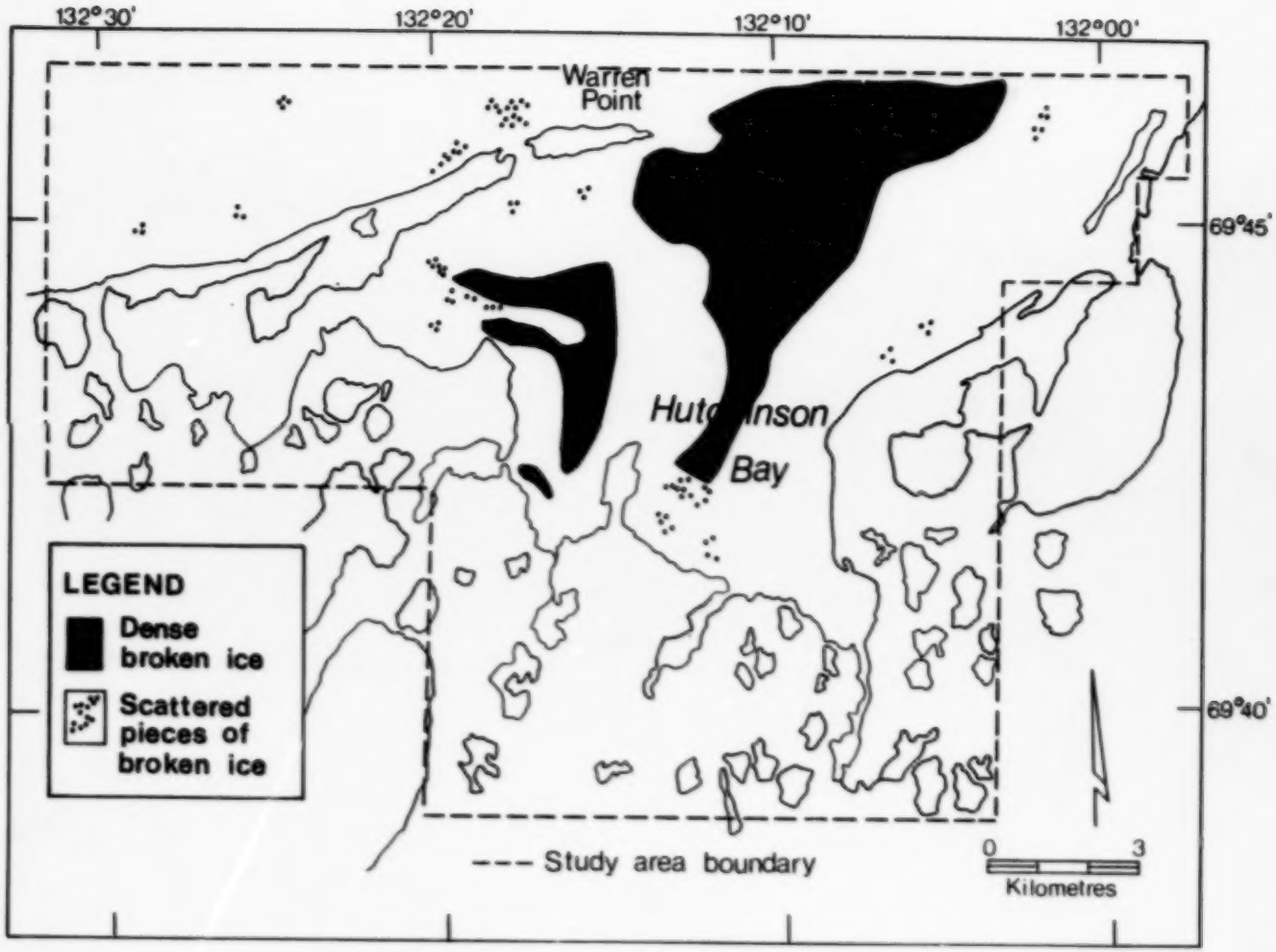


Figure 4. Ice conditions at Hutchison Bay during the aerial survey on August 4, 1985.

totally ice-free or had scattered fragments of ice. Photographs taken from the survey plane helped assess the extent of the ice.

### 3.2 Abundance, 1985 survey

#### 3.2.1 Marine Component

Numbers and densities of birds seen on the marine components of McKinley Bay and Hutchison Bay, in 1985, are presented in Table 2. Overall densities of birds, particularly diving ducks, counted on the marine component at McKinley Bay were less than at Hutchison Bay. At McKinley Bay, the observed density of diving ducks was 64.18 birds/$km^2$, while at Hutchison Bay, 101.18 divers/$km^2$ were observed.

Table 3 gives the species composition and densities of diving ducks observed at each bay. At both bays, over 90% of all identified diving ducks were Oldsquaw or scoters, although the relative numbers of Oldsquaw and scoters varied between the two bays. At McKinley Bay, Oldsquaw represented 82% of identified diving ducks, while only about 12% of all identified divers were scoters. At Hutchison Bay, Oldsquaw and scoters were seen in nearly equal proportions, although slightly more Oldsquaw were observed. Other diving duck species seen in small numbers in both bays were scaup (6% of identified divers), Red-breasted Mergansers and eiders (both less than 1% of identified divers).

Population estimates of diving duck species observed on the marine component of both bays are given in Table 4. The estimated population of diving ducks on the marine component of McKinley Bay on

Table 2. Number and density of birds observed on the marine component at McKinley Bay and Hutchison Bay during aerial surveys on August 4, 1985.

| Species group | McKinley Bay[a] | | Hutchison Bay[b] | |
|---|---|---|---|---|
| | Number | Density (birds/km$^2$) | Number | Density (birds/km$^2$) |
| Loons | 45 | 2.30 | 22 | 1.24 |
| Swans | 0 | 0.00 | 0 | 0.00 |
| Geese | 5 | 0.26 | 49 | 2.75 |
| Dabbling ducks | 23 | 1.17 | 0 | 0.00 |
| Diving ducks | 1258 | 64.18 | 1801 | 101.18 |
| Unidentified ducks | 4 | 0.20 | 28 | 1.57 |
| Shorebirds | 2 | 0.10 | 0 | 0.00 |
| Gulls | 12 | 0.61 | 21 | 1.18 |
| Terns | 0 | 0.00 | 1 | 0.06 |
| TOTAL BIRDS | 1349 | 68.83 | 1922 | 107.98 |

[a]Area surveyed = 19.6 km$^2$.
[b]Area surveyed = 17.8 km$^2$.

Table 3. Species composition and density of diving ducks observed on the marine component at McKinley Bay and Hutchison Bay on August 4, 1985.

| Species | McKinley Bay[a] | | | Hutchison Bay[b] | | |
|---|---|---|---|---|---|---|
| | Number | Percent | Density (birds/km$^2$) | Number | Percent | Density (birds/km$^2$) |
| Oldsquaw | 996 | 82.0 | 50.82 | 872 | 49.1 | 48.99 |
| Scoter sp. | 148 | 12.2 | 7.55 | 785 | 44.2 | 44.10 |
| Scaup sp. | 70 | 5.8 | 3.57 | 102 | 5.8 | 5.73 |
| Eider sp. | 1 | <0.1 | 0.05 | 11 | 0.6 | 0.62 |
| Red-breasted Merganser | 0 | 0.0 | 0.00 | 6 | 0.3 | 0.34 |
| TOTAL IDENTIFIED DIVING DUCKS | 1215 | 100.0 | 61.99 | 1776 | 100.0 | 99.78 |
| Unidentified diving ducks | 43 | - | 2.19 | 25 | - | 1.40 |

[a]Area surveyed = 19.6 km$^2$.
[b]Area surveyed = 17.8 km$^2$.

Table 4. Population estimates of the diving ducks on the marine component at McKinley Bay and Hutchison Bay on August 4, 1985.

| Species | Location | Total count on all transects | Density (birds/km$^2$) | Population estimate | Standard error of population estimate |
|---|---|---|---|---|---|
| Oldsquaw | McKinley Bay | 996 | 50.82 | 5514 | 1533 |
| | Hutchison Bay | 872 | 48.99 | 4924 | 1306 |
| Scoter sp. | McKinley Bay | 148 | 7.55 | 819 | 127 |
| | Hutchison Bay | 785 | 44.10 | 4432 | 2049 |
| Scaup sp. | McKinley Bay | 70 | 3.57 | 387 | 242 |
| | Hutchison Bay | 102 | 5.73 | 576 | 349 |
| Eider sp. | McKinley Bay | 1 | 0.05 | - | - |
| | Hutchison Bay | 11 | 0.62 | 62 | 14 |
| Red-breasted Merganser | McKinley Bay | 0 | 0.00 | - | - |
| | Hutchison Bay | 6 | 0.34 | 34 | 15 |
| TOTAL DIVERS[a] | McKinley Bay | 1258 | 64.18 | 6 964 | 1382 |
| | Hutchison Bay | 1801 | 101.18 | 10 169 | 1120 |

[a]Includes unidentified divers.

August 4, 1985, was 6964 ± 1382 (standard error). At Hutchison Bay, the population of diving ducks was estimated to be 10 169 ± 1120.

A list of common and scientific names of observed species is presented in Appendix A.

### 3.2.2 Terrestrial Component

Table 5 lists the numbers and densities of birds observed on the terrestrial components of McKinley and Hutchison bays in 1985. More species were represented on the terrestrial component at both bays than on the marine component. Overall densities of birds using the terrestrial component at McKinley Bay in 1985 were less than at Hutchison Bay.

**McKinley Bay**

Diving ducks, which were the most abundant species group on the McKinley Bay terrestrial component, were recorded in densities of 6.82 birds/km$^2$ (Table 5). About 54% of the identified diving ducks were Oldsquaw, while only 11% were scoters. Red-breasted Mergansers were the second most abundant diver on the terrestrial component, representing 26% of identified divers.

Dabbling ducks were observed in densities of 5.76 birds/km$^2$ (Table 5). Nearly all dabblers that were identified to species were Northern Pintail (84%), although American Wigeon were also seen.

Observers saw 4.56 geese/km$^2$ (Table 5), and identified two species of geese (Brant and Greater White-fronted Geese) on the terrestrial component. Tundra Swans were scattered on the lakes and

Table 5. Number and density of birds observed on the terrestrial component at McKinley Bay and Hutchison Bay during aerial surveys on August 4, 1985.

| Species group | McKinley Bay[a] | | Hutchison Bay[b] | |
|---|---|---|---|---|
| | Number | Density (birds/km$^2$) | Number | Density (birds/km$^2$) |
| Loons | 31 | 1.09 | 69 | 4.23 |
| Swans | 61 | 2.16 | 48 | 2.94 |
| Geese | 129 | 4.56 | 96 | 5.89 |
| Dabbling ducks | 163 | 5.76 | 337 | 20.67 |
| Diving ducks | 193 | 6.82 | 88 | 5.40 |
| Unidentified ducks | 99 | 3.50 | 0 | 0.00 |
| Raptors | 0 | 0.00 | 1 | 0.06 |
| Ptarmigan | 1 | 0.04 | 7 | 0.43 |
| Cranes | 5 | 0.18 | 0 | 0.00 |
| Shorebirds | 54 | 1.91 | 82 | 5.03 |
| Jaegers | 2 | 0.07 | 0 | 0.00 |
| Gulls | 41 | 1.45 | 35 | 2.15 |
| Terns | 8 | 0.28 | 0 | 0.00 |
| Passerines | 22 | 0.78 | 10 | 0.61 |
| TOTAL BIRDS | 809 | 28.59 | 773 | 47.42 |

[a]Area surveyed = 28.3 km$^2$.
[b]Area surveyed = 16.3 km$^2$.

ponds of the terrestrial component in densities of 2.16 swans/km$^2$. Two species of loons were identified, Red-throated Loons (82%) and Arctic Loons. The overall density of loons on the terrestrial component at McKinley Bay was 1.09 birds/km$^2$.

**Hutchison Bay**

Dabbling ducks represented the largest proportion of birds seen on the Hutchison Bay terrestrial component. A density of 20.67 dabblers/km$^2$ (Table 5) was observed, representing 44% of all birds counted on the terrestrial component. As at McKinley Bay, most of these dabblers were Northern Pintail (81%). The American Wigeon was the only other dabbling duck species identified.

Only 88 diving ducks were counted on the Hutchison Bay terrestrial component, which represented a density of 5.40 birds/km$^2$ (Table 5). The largest proportion of identified divers were Red-breasted Mergansers (34%), while Oldsquaw, scoters and scaup, listed in order of abundance, were also seen.

A density of 5.89 geese/km$^2$ (Table 5) was observed on the terrestrial component. Of a total of 71 geese identified to species, 56% were Brant and the remainder were Greater White-fronted Geese. Loons were seen in densities of 4.23 birds/km$^2$ on the Hutchison Bay terrestrial component, and both Red-throated Loons (63% of identified loons) and Arctic Loons were identified. Observers saw a total of 69 swans (2.94 birds/km$^2$).

### 3.3 Comparison of Surveys, 1981 to 1985

The overall density estimates for Oldsquaw, scoters and total divers observed each year from 1981 to 1985 on the marine components at McKinley Bay and Hutchison Bay are presented in Table 6. The mean and 95% confidence interval for species at each bay are also given.

Tables 7 and 8 summarize the results of the non-parametric Kruskal-Wallis test (Conover 1980). At McKinley Bay, significantly lower densities of both scoters ($p<0.10$) and total divers ($p<0.05$) were observed in 1985 than in any of the other years of the study (Table 7). At Hutchison Bay, the density of observed Oldsquaw was significantly greater ($p<0.05$) in 1984 than in any other year (Table 8). Oldsquaw densities dropped significantly from the 1984 survey to the 1985 survey, but the observed density in 1985 was still significantly greater than in 1983. Observed densities of total divers at Hutchison Bay followed approximately the same pattern of fluctuation as Oldsquaw, with the exception of the 1983 densities, which were not significantly different from 1985 (Table 8).

Table 9 gives the mean and range of densities of the common species observed on the terrestrial component, during August surveys from 1981 to 1985. However, these averages may be misleading for some species groups. Numbers of observed geese tended to vary greatly from one survey to another, since these birds were often seen in large groups on only one or two transects. Thus, the chances of missing a large group which may have moved off transect may alone account for observed variation. The density of diving ducks on the Hutchison Bay terrestrial

Table 6. Densities of diving ducks observed on the marine components at McKinley Bay and Hutchison Bay from 1981 to 1985.

| Species | Year | Overall densities | |
|---|---|---|---|
| | | McKinley Bay (birds/km$^2$) | Hutchison Bay (birds/km$^2$) |
| Oldsquaw | 1981 | 46.43 | n.d.[a] |
| | 1982 | 54.23 | 43.71 |
| | 1983 | 41.53 | 32.47 |
| | 1984 | 46.58 | 83.59 |
| | 1985 | 50.82 | 48.99 |
| | $\bar{x} \pm$ 95% C.L.[b] | 47.92 $\pm$ 5.99 | 52.19 $\pm$ 35.06 |
| Scoters | 1981 | 31.22 | n.d. |
| | 1982 | 40.05 | 64.94 |
| | 1983 | 50.51 | 88.26 |
| | 1984 | 74.80 | 56.52 |
| | 1985 | 7.55 | 44.10 |
| | $\bar{x} \pm$ 95% C.L. | 40.83 $\pm$ 30.70 | 63.46 $\pm$ 29.62 |
| Total divers[c] | 1981 | 110.82 | n.d. |
| | 1982 | 114.59 | 133.99 |
| | 1983 | 117.96 | 135.67 |
| | 1984 | 158.37 | 172.25 |
| | 1985 | 64.18 | 101.18 |
| | $\bar{x} \pm$ 95% C.L. | 113.18 $\pm$ 41.53 | 135.77 $\pm$ 53.70 |

[a]No data; Hutchison Bay not surveyed in 1981.

[b]$\bar{x}$ = mean over all years; C.L. = 95% confidence limits.

[c]Includes to all species of diving ducks.

Table 7. Results of Kruskal-Wallis comparisons of obeserved densities of diving ducks at McKinley Bay between 1981 and 1985.

| | Comparison (all possible pairs of years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Species | 1985-81 | 1985-82 | 1985-83 | 1985-84 | 1984-83 | 1984-82 | 1984-81 | 1983-82 | 1983-81 | 1982-81 |
| Oldsquaw | - n o s i g n i f i c a n t v a r i a t i o n - (Krustal-Wallis: $p \geq 0.10$, Appendix E) | | | | | | | | | |
| Scoter sp. | $p<0.10$ | $p<0.10$ | $p<0.05$ | $p<0.05$ | ns[a] | ns | ns | ns | ns | ns |
| Total divers[b] | $p<0.05$ | $p<0.05$ | $p<0.05$ | $p<0.05$ | ns | ns | ns | ns | ns | ns |

[a]ns = non-significant; $p \geq 0.10$.

[b]Includes all species of diving ducks.

Table 8. Results of Kruskal-Wallis comparisons of observed densities of diving ducks at Hutchison Bay between 1982 and 1985.

| | Comparison (all possible pairs of years) | | | | | |
|---|---|---|---|---|---|---|
| Species | 1985-82 | 1985-83 | 1985-84 | 1984-82 | 1984-83 | 1983-82 |
| Oldsquaw | ns[a] | $p<0.05$ | $p<0.05$ | $p<0.05$ | $p<0.05$ | ns |
| Scoter sp. | - no significant variation - (Kruskal-Wallis: $p \geq 0.10$) | | | | | |
| Total divers[b] | ns | ns | $p<0.05$ | $p<0.05$ | $p<0.05$ | ns |

[a]ns = non-significant; $p \geq 0.10$.

[b]Includes all species of diving ducks.

Table 9. Average densities of birds observed on the McKinley Bay and Hutchison Bay terrestrial components during aerial surveys in August from 1981 to 1985.[a]

| | McKinley Bay (1981-1985) | | Hutchison Bay (1982-1985) | |
|---|---|---|---|---|
| Species group | Average (birds/km$^2$) | Range (birds/km$^2$) | Average (birds/km$^2$) | Range (birds/km$^2$) |
| Loons | 1.45 | (1.09 - 2.01) | 2.68 | (1.53 - 4.23) |
| Swans | 1.80 | (1.17 - 2.58) | 2.60 | (1.04 - 4.60) |
| Geese | 4.15 | (1.84 - 5.12) | 2.67 | (0.00 - 5.89) |
| Dabbling ducks | 5.70 | (2.76 - 7.77) | 7.93 | (1.29 -20.67) |
| Diving ducks | 8.23 | (5.86 -12.23) | 4.80 | (0.18 -11.60) |
| Gulls | 1.62 | (1.24 - 2.05) | 2.36 | (1.35 - 3.01) |

[a]Based on the results from the survey with the best conditions each year.

component ranged widely, from a low of 0.18 birds/km$^2$ in 1984 to a high of 11.60 birds/km$^2$ in 1983. Similarly, the density of dabblers observed at Hutchison Bay in 1985 (20.67 birds/km$^2$ on the terrestrial component) was more than five times the average density recorded for the three years prior to 1985 (average density for 1982 to 1984 was 3.68 birds/km$^2$).

### 3.4 Distribution, 1985 survey

#### 3.4.1 McKinley Bay

The distribution of selected waterfowl groups, observed during the aerial survey at McKinley Bay on August 4, 1985, is presented in Figure 5. Isolated groups of less than 10 diving ducks are not illustrated.

**Diving ducks**

Much of McKinley Bay was still ice-covered during the survey on August 4, 1985. This affected the distribution of birds on the marine component (Figs. 3 and 5). Waterfowl were observed mainly in the larger open water areas, but also in small patches of open water within extensive areas covered with dense brash ice.

The area of open water along the east shore of McKinley Bay supported the largest concentrations of diving ducks in 1985 (Fig. 5). Two large flocks of divers were seen on transect 4 in this area (including 75 Oldsquaw and 50 scaup), as well as several small flocks of divers. Although much of the area between Atkinson Point and the artificial island was covered with ice fragments (Fig. 3), a large flock

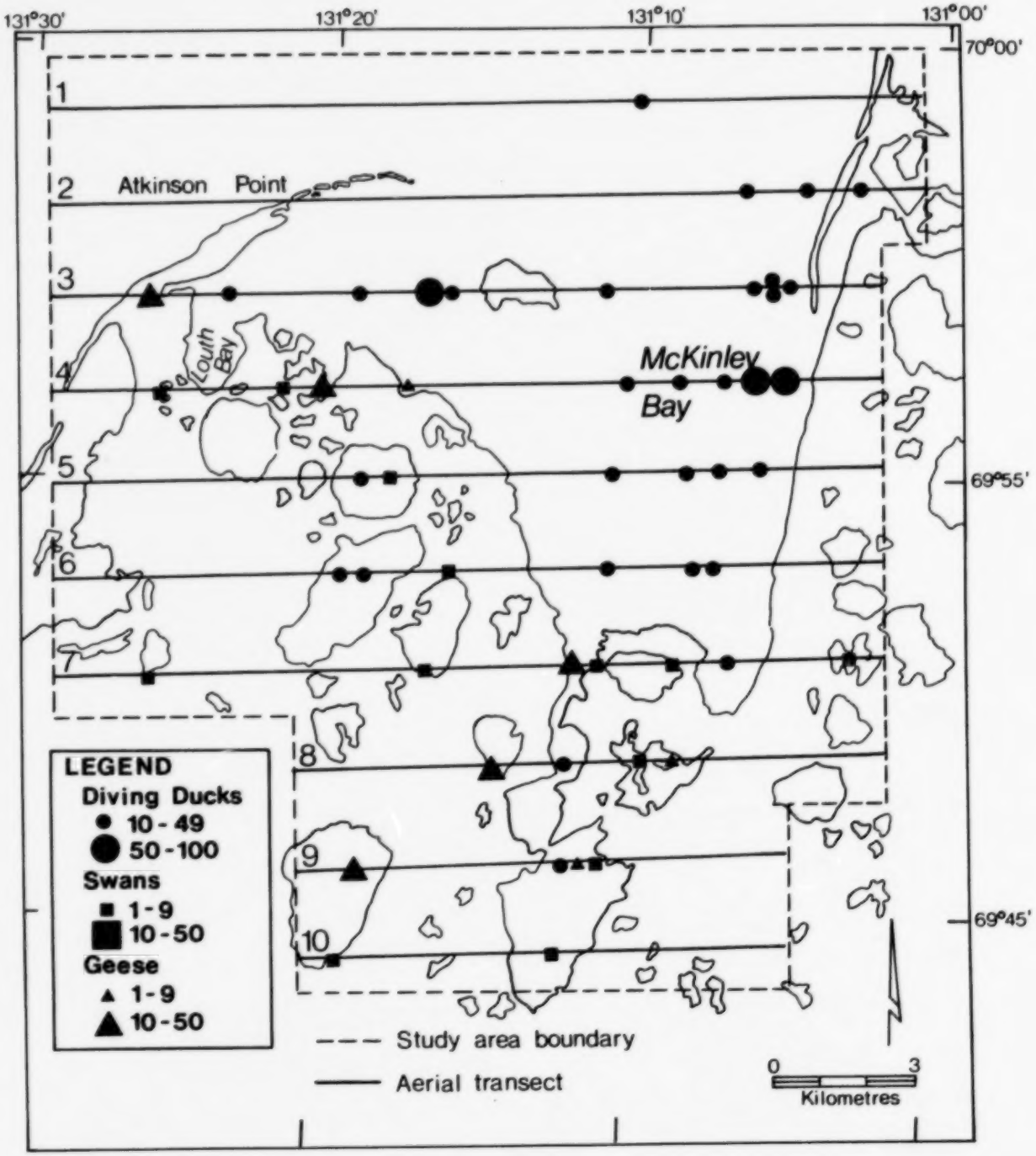


Figure 5. Distribution of waterfowl observed on aerial transects at McKinley Bay on August 4, 1985.

of 120 Oldsquaw was observed just west of the island (Figs. 3 and 5). Small flocks of Oldsquaw were scattered throughout the bay wherever there was open water.

Unlike other years, no large flocks of more than 50 scoters were seen in McKinley Bay in 1985. Only 148 scoters were observed in total. The greatest number of scoters seen on a single transect was on transect 6, where 40 scoters were seen scattered in small flocks.

The lakes and ponds of the terrestrial component were ice-free at the time of the survey, as was most of the lagoon system that enters the south end of McKinley Bay. Most of the diving ducks seen on the terrestrial component were Oldsquaw, primarily in small groups on two large lakes southwest of McKinley Bay. Red-breasted Mergansers were seen only on the lagoon system, where a total of 46 were counted. Oldsquaw also utilized this area in small numbers.

**Other waterfowl**

Most of the geese at McKinley Bay were in the sheltered lagoons. In the littoral area of a small lagoon north of Louth Bay, observers saw 30 Brant (Fig. 5). On the tidal flats east of Louth Bay, there were 10 dark geese. Five more dark geese were on the open shoreline of McKinley Bay directly east of these flats. There were 35 dark geese, 8 Brant and 1 Greater White-fronted Goose on or near the large lagoon at the south end of McKinley Bay. Geese were also seen on two large lakes in the southwest corner of the study area: 15 dark geese on transect 8 and 31 Greater White-fronted Geese on transect 9.

Tundra Swans were fairly evenly distributed, in pairs and family groups, over the entire terrestrial component. They were seen on lakes, ponds and shallow lagoon systems.

Dabbling ducks, especially Northern Pintail, were scattered in various areas of the terrestrial component. They were seen mainly on small tundra ponds and on tidal flats.

### 3.4.2 Hutchison Bay

Figure 6 shows the distribution of selected waterfowl groups during the aerial survey at Hutchison Bay on August 4, 1985.

**Diving ducks**

Most of the eastern section of Hutchison Bay was either ice-free or had small scattered pieces of broken ice (Fig. 4). The heaviest ice was in a wide section in the center of the bay. The largest concentrations of divers were in the area of open water along the eastern shore. A large flock of 400 Surf Scoters was seen here on transect 2, near a long narrow sandspit in the northeastern section of the bay (Fig. 6). Over 200 Oldsquaw and 100 scoters were also seen on transect 3, close to the eastern shoreline. A concentration of 150 Oldsquaw was found in a patch of open water in the north-central part of the bay, within the area of dense brash ice. Oldsquaw and scoters were otherwise in small flocks wherever there was open water, throughout the bay. Nearly all scaup and eiders on the marine component were seen near the western arm, or close to Warren Point. The six Red-breasted Mergansers seen on the marine component were close to shore.

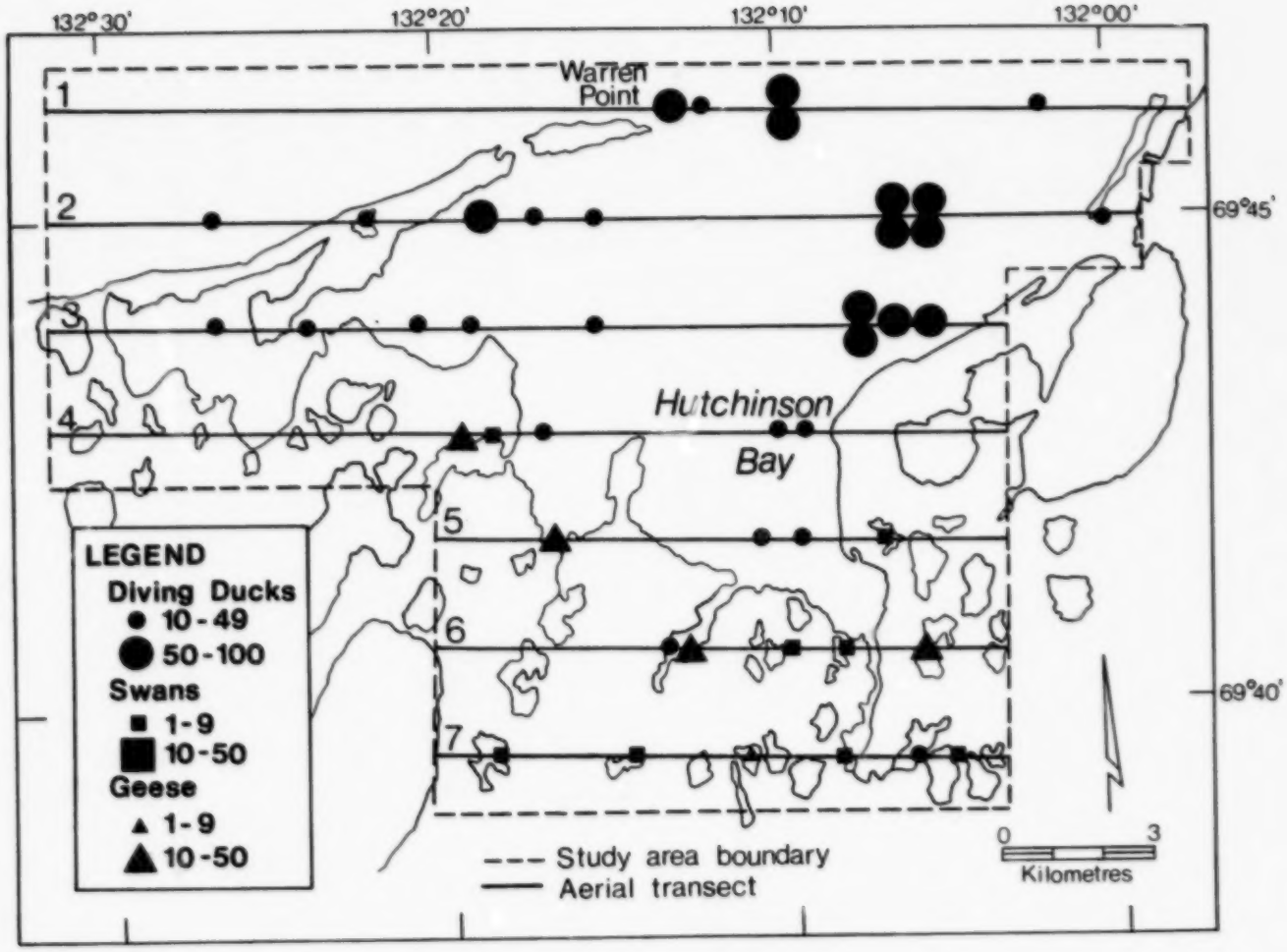


Figure 6. Distribution of waterfowl observed on aerial transects at Hutchison Bay on August 4, 1985.

Only a few small groups of divers were recorded on the terrestrial component at Hutchison Bay. A group of 12 Oldsquaw and 20 White-winged Scoters were observed on ponds at the base of Warren Point, on transect 2. Thirty Red-breasted Mergansers were seen on a lake at the southeast corner of the study area, along with 12 Oldsquaw. A group of 12 scaup utilized a long brackish channel of the bay in the southwest corner of the study area.

**Other waterfowl**

Geese were observed on tidal flats in the more sheltered areas of the bay and also on small lakes. Three groups of geese (25 Brant, 12 adult and 12 young Lesser Snow Geese, and a group of 40 Brant) were seen on transects 4 and 5, near a little bay west of the peninsula that juts into the southwest section of Hutchison Bay (Fig. 6). A group of 25 Greater White-fronted Geese was seen on a small lake on transect 6, and six Greater White-fronted Geese were on a lake on transect 7.

Tundra Swans were distributed on lakes and ponds, mainly in the southern half of the study area, as well as on shallow lagoon channels of the bay. Dabbling ducks were seen throughout the terrestrial component, but large numbers were concentrated in two areas: about 60 dabblers in the small embayment crossed by transects 4 and 5, and a group of 220 Northern Pintails on a shallow lake at the west end of transect 6.

### 3.5 Patterns of Waterfowl Distribution, 1981-1984

From the distribution data collected during the August surveys of all years of this study, it was apparent that certain regions of the

study areas were more heavily used by waterfowl than other regions. Figures 7 and 8 summarize the observed distribution of waterfowl in McKinley Bay and Hutchison Bay study areas, respectively, during August surveys from 1982 through 1984. The information presented in these figures represents average counts per 1-minute interval (timed on each transect during the aerial surveys). Data from the "best" August survey each year, for the 3 years from 1982 to 1984, were used. Because ice covered much of these bays during the 1985 survey, the 1985 data were not included in Figures 7 and 8. Also, detailed distribution data by the minute interval were not available for 1981 at McKinley Bay.

### 3.5.1 McKinley Bay

Diving ducks in McKinley Bay concentrated primarily in two areas: between Atkinson Point and the artificial island, and at the south end of the bay on transects 5, 6 and 7 (Fig. 7). The average density of diving ducks counted in these areas was more than 100 birds/km$^2$.

Although Figures 7 and 8 refer to counts of total diving ducks, there were some notable differences in the way scoters and Oldsquaw were distributed. In general, scoters tended to concentrate heavily at the south end of the bay or near Atkinson Point, or in both of these two areas. Oldsquaw, however, were less often seen at the south end of the bay and tended to concentrate in the Atkinson Point area or else were more evenly distributed across the bay.

During the 1984 August surveys, 94% of all scoters were either in the Atkinson Point area or at the south end of the bay on transects 5, 6

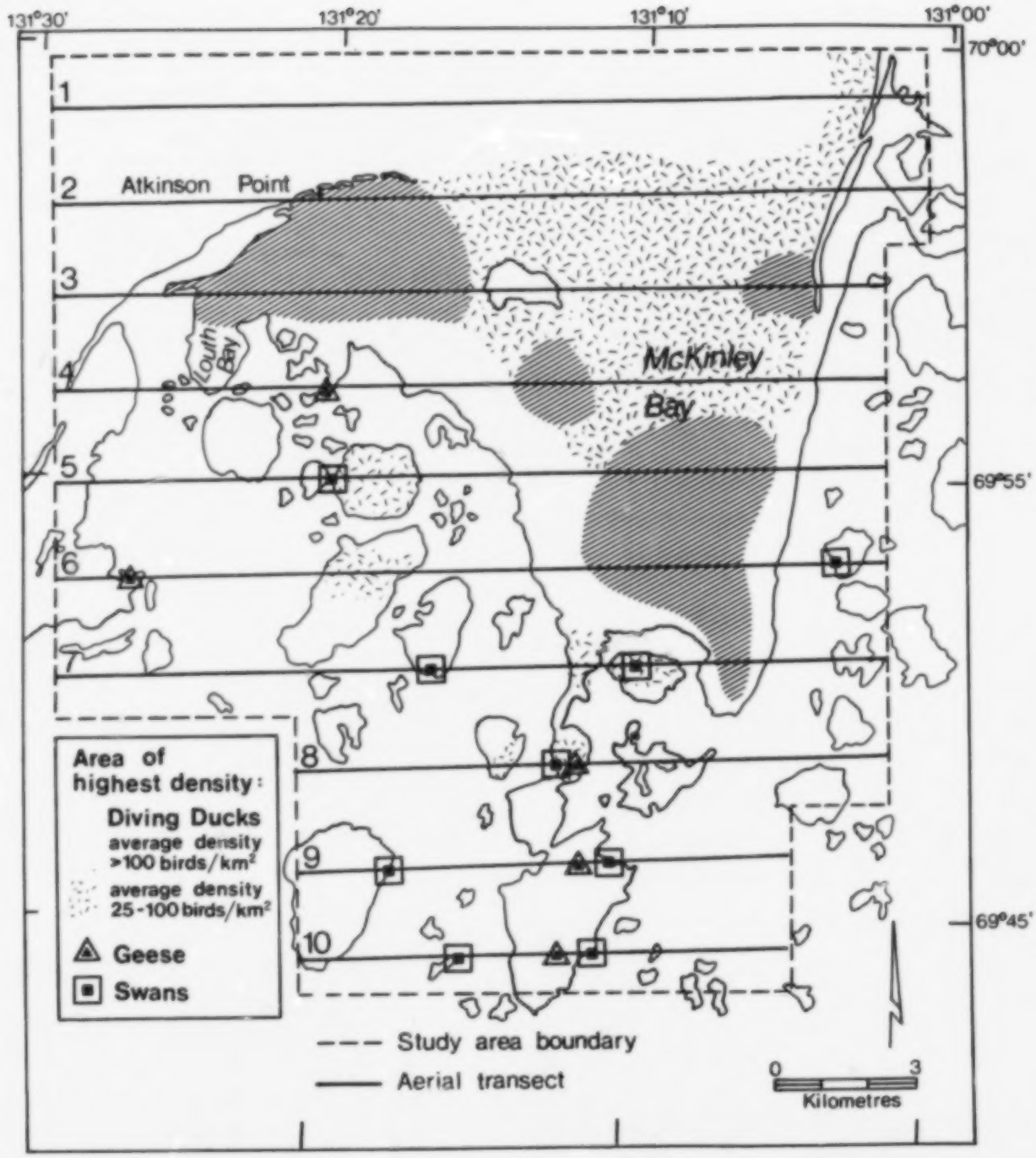


Figure 7. Areas important for waterfowl in the McKinley Bay study area, based on frequency of observations during aerial surveys from 1982 to 1984.

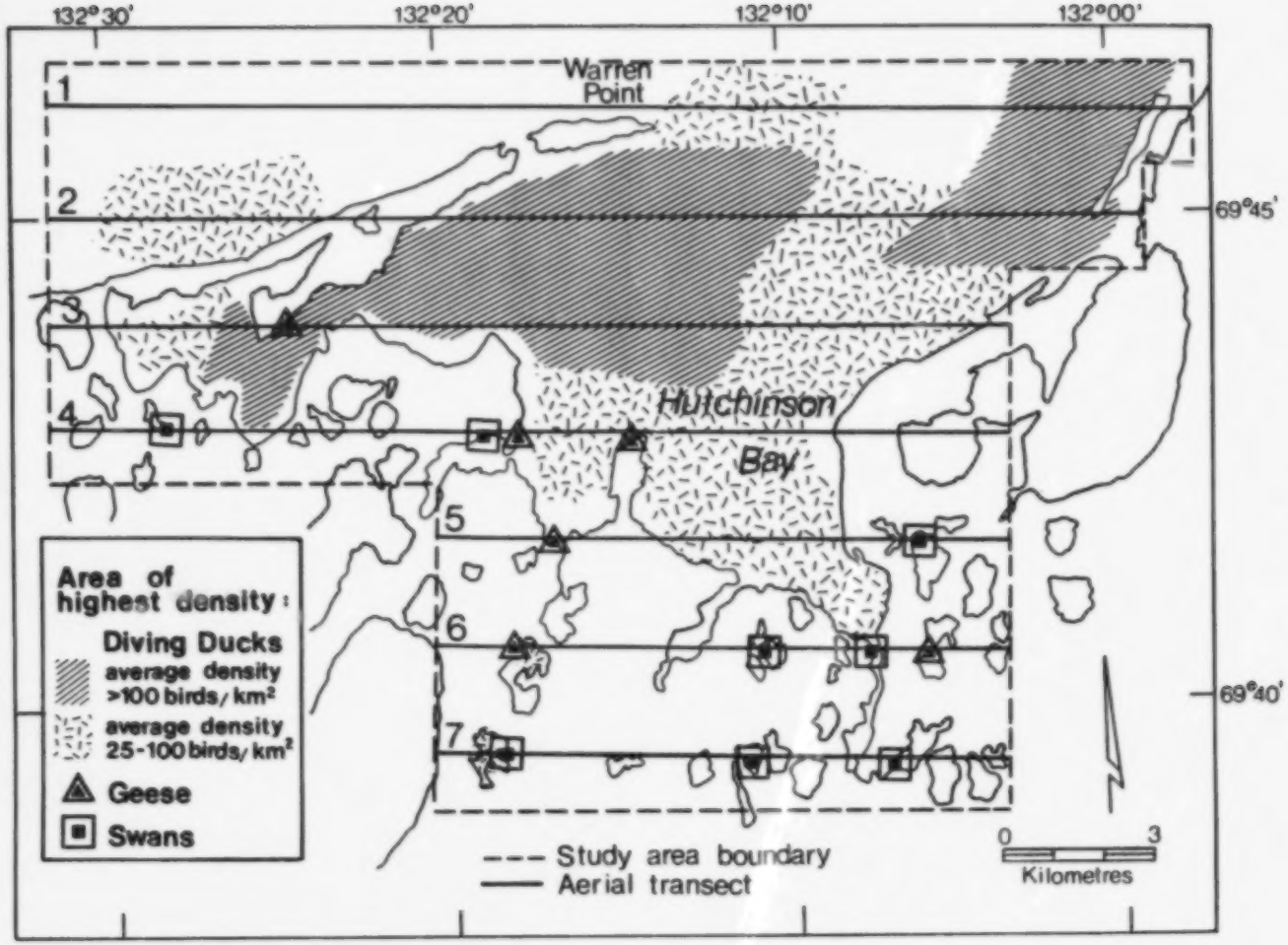


Figure 8. Areas important for waterfowl in the Hutchison Bay study area, based on frequency of observations during aerial surveys from 1982 to 1984.

or 7. Also, on August 5 in 1983, the concentrations of divers at the south end (transects 5, 6 and 7) were mainly scoters; only 5% of the total Oldsquaw (41/814) observed on that survey were at the south end, while 50% (491/990) of observed scoters were on these three short transects. During boat surveys conducted in 1982, observers frequently noted very large flocks of up to 500 scoters at the south end of the bay. Similarly, a series of helicopter surveys during three days in mid-August, 1982, indicated an overall average of 77% of observed scoters were in the south end of the bay, but only 15% of the Oldsquaw. On August 10, 1981, Oldsquaw and scoters were present at the south end in approximately equal numbers, but no large concentrations of either species were noted.

Both Oldsquaw and scoters utilized the Atkinson Point area, although observers usually saw more Oldsquaw in this area than scoters. Large numbers of diving ducks were observed near Atkinson Point on August 10, 1981, and the ratio of Oldsquaw to scoters was about 3:2. On the August 10 aerial survey in 1982, about 50% of the total observed Oldsquaw were in the Atkinson Point area. On August 5, 1983, there were twice as many Oldsquaw as scoters in this area. However, on August 3, 1984, when nearly half of all divers observed were in the Atkinson Point area, 65% of these divers were scoters.

A small number of mergansers and scaup were seen annually at McKinley Bay. Both species were rarely seen more than 500 m from shore.

Although few eiders were seen during the annual aerial surveys at McKinley Bay, the Atkinson Point area was utilized by a large influx of

eiders in mid-summer, 1982. Between July 23 and August 4, 1984, up to 370 eiders were counted in this location during daily shoreline surveys. However, after August 10, there were only a few sightings of one or two eider on shoreline surveys and no large flocks of eiders were subsequently seen anywhere in the bay during boat, fixed-wing or helicopter surveys in 1982. Apparently these eiders utilized the Atkinson Point area as a stopover during migration.

Two smaller areas in McKinley Bay where the average observed density was more than 100 birds/km$^2$ were just south of the artificial island, on transect 4, and at the south end of a long spit on the eastern shoreline. Both Oldsquaw and scoters utilized these areas, but Oldsquaw were usually seen in greater numbers.

Groups of geese or swans were also seen repeatedly in the same areas from year to year. Locations where groups of geese or swans were seen in more than one year were considered important for that species, and were outlined on Figures 7 and 8. At McKinley Bay, geese favoured the tidal flats east of Louth Bay and the lagoon at the south end of McKinley Bay. Swans favoured lakes and ponds, as well as the lagoon at the south end of the bay (Fig. 7).

### 3.5.2 Hutchison Bay

The highest average densities of divers at Hutchison Bay were in the northeast section of the bay, as well as in a large area south of Warren Point (Fig. 8). Densities of diving ducks in these areas averaged more than 100 birds/km$^2$.

The high densities of divers in the northeast section represent repeated sightings of very large flocks of scoters. On August 10, 1982, a raft of 730 Surf Scoters observed in this area, on transect 2, accounted for over 60% of scoters observed on that survey. On surveys in 1983 and 1984, flocks of about 300 scoters were seen in the northeast section of the bay on both transects 1 and 2.

Many diving ducks were seen south of the Warren Point sandspit and in the anvil-shaped western arm of the bay. About equal numbers of Oldsquaw and scoters occurred there. Up to 50 scaup were seen on surveys in 1983 and 1984 in a location at the south end of the western arm, on transect 4. Flocks of 15 to 130 Red-breasted Mergansers were recorded each year, from 1982 to 1984, near the long narrow peninsula that juts into the southwest region of the bay.

The little bay west of the long narrow peninsula, in the southwest section of the bay, was clearly an important area for geese (Fig. 8). Sightings of Brant, Lesser Snow Geese, or unidentified "dark geese" were noted in this little bay each year, from 1982 to 1984. The largest group of geese recorded was 60 Brant, on August 3, 1984. Both adult and immature geese were observed in this area. Brant also utilized the shoreline area near the western arm of the bay, and small flocks of 15 to 25 Greater White-fronted Geese consistently used a few small lakes on the terrestrial component. Tundra Swans were seen on lakes, ponds and shallow lagoon channels (Fig. 8).

### 3.6 Flock Sizes of Oldsquaw and Scoters

It was evident from the data from 1982 to 1985 that scoters occurred in large flocks (greater than 50 birds) more frequently than Oldsquaw. Over 40% of scoters were in large flocks of more than 50 birds on August 10, 1982 at McKinley Bay, while at Hutchison Bay on the same day, 93% of observed scoters were in these large aggregations. Few large flocks of scoters were seen during August surveys in 1983 at McKinley Bay, but at Hutchison Bay on both August 5 and 6 in 1983, more than 50% of scoters were in large flocks. During the August surveys in 1984 at McKinley Bay and the survey on August 4 in 1985 at Hutchison Bay, over 60% of all scoters were observed in flocks of over 50 birds.

In comparison, Oldsquaw were more often seen scattered in groups of 10 birds or less, and seldom in large flocks. During most August surveys at both bays, less than 25% of Oldsquaw were in large flocks of more than 50 birds.

## 4.0 DISCUSSION

Large numbers of diving ducks, primarily Oldsquaw and scoters, migrate to McKinley Bay and Hutchison Bay each year to undergo the annual wing-moult. On the average during the five years of this study, over 12 000 diving ducks utilized McKinley Bay in early August each year, while an average of over 13 000 diving ducks utilized Hutchison Bay.

The existence of moulting areas separate from the nesting grounds is an ecological adaptation that serves to ultimately increase brood

survival in diving ducks (Salomonsen 1968). Breeding males and immature non-breeders of both sexes (1-2 years) leave the nesting areas and migrate to other areas to moult, whereas many breeding females moult near the nesting grounds (Palmer 1972). This segregration of age and sex classes during wing-moult reduces competition for food on the nesting grounds. However, the moulting diving ducks on the coastal moulting areas are concentrated, and therefore, vulnerable to an oil spill in their habitat.

Nesting areas may be adjacent to or distant from the moulting areas. Oldsquaw are a common nesting bird in the arctic tundra, while scoters nest in the boreal forest and apparently do not nest to any significant extent along the arctic coast (Arner et al. 1985; Bellrose 1980; Cornish and Allen 1983; Dickson 1985; Martel 1975; Salter et al. 1980).

Densities of Oldsquaw at McKinley Bay remained fairly constant from 1981 to 1985, while densities of scoters were more variable from year to year. Significant changes in scoter numbers, however, were detected only in 1985 ($p < 0.10$; Table 8). At Hutchison Bay, there was variation in observed densities of both Oldsquaw and scoters over the four years of surveys, although significant changes were detected only for Oldsquaw ($p < 0.05$; Table 9).

The large variation in numbers of diving ducks counted during the aerial surveys may be the result of several factors, including the timing of the initiation of the moult, nesting success, ice conditions in the bays, and large flock size.

The number of diving ducks using the coastal bays in early August partly depends on the proportion of birds that have commenced the moult. The first 15 days of August was the peak period of moult for Oldsquaw in McKinley Bay in 1982, based on daily shoreline surveys that recorded numbers of birds flushing. However, the timing of the moult for a species may vary between years and probably depends on timing of breeding and nest initiation (Salomonsen 1968). At Simpson Lagoon in the Alaskan Beaufort Sea, Johnson and Richardson (1981) found that the moult for a large proportion of both male and female Oldsquaw evidently began up to two weeks earlier in 1978 than in 1977, based on wing measurements. The peak of the moult was less distinct in 1978, because the moult extended over a longer period of time than in 1977.

Nesting success in any year may also affect numbers of divers in the moulting areas in early August. According to Palmer (1972), pre-breeding yearlings or non-breeding birds of both sexes would be the earliest of the diving ducks to become flightless, followed by drakes of breeding pairs, then failed breeders. Johnson and Richardson (1981) noted an influx of female Oldsquaw, apparently failed breeders, into Simpson Lagoon between August 7 and 18 in 1977 and 1978. If these divers represent failed breeders, then the total number of Oldsquaw arriving in the moulting areas in early to mid-August is probably related to nesting success that year. When large numbers of nests are lost due to, for example, storms or predation, the population of diving ducks in these bays could be boosted by many failed breeding females.

The site selected for annual moult may also shift, depending on the ice conditions in the bays and lagoons when the birds first arrive to moult in July (Barry et al. 1981). During our aerial surveys on August 4, 1985, ice covered an estimated one-third of both McKinley and Hutchison bays. Numbers of scoters counted at McKinley Bay on August 4, 1985, were only one-tenth the total counted on August 3, 1984. Conversely, unusually high numbers of divers were seen in mid-summer, 1985, in nearby Liverpool Bay and the Eskimo Lakes, which were ice-free (T. Barry pers. comm.). Many scoters that traditionally moult in McKinley Bay may have been displaced to such ice-free areas as Liverpool Bay and Eskimo Lakes in the summer of 1985.

Divoky (1977) studied the distribution of seabirds, including Oldsquaw and eiders, in relation to pack ice in the Alaskan Beaufort Sea. Divoky listed several ways that the presence of sea ice can enhance or decrease seabird numbers. Sea ice can cause conditions to be less favourable for seabirds, by limiting the amount of open water available for feeding and roosting, decreasing the primary productivity in the water column, allowing less wind-mixing of nutrients used by invertebrate prey species, and decreasing benthic prey species directly through ice-scouring of the bottom. Conversely, sea ice can cause conditions that enhance the numbers of these diving ducks, and affect the distribution of the divers, by providing loafing sites on the ice, allowing the growth of ice-associated communities of phytoplankton and invertebrates, and by decreasing wind and wave disturbance in the vicinity of the ice (Divoky 1977).

It is unknown why numbers of scoters were so drastically reduced in 1985, when ice covered much of the two bays, while Oldsquaw generally maintained their previous levels. It may be because Oldsquaw are more opportunistic than scoters in their feeding habits. Oldsquaw will apparently take whatever organisms are most available to them, including epibenthic crustaceans (Johnson 1984; Peterson and Ellarson 1977), Capelin eggs during the spawning season of this fish (Gjosaeter and Saeter 1974 in Johnson 1984), locally abundant minnows (Ellarson 1956) and sculpins (LGL 1983). Sanger and Jones (1984) concluded, from winter studies in Alaska, that Oldsquaw were generalists in their feeding habits, feeding on more than 61 prey species. Several researchers have noted Oldsquaw actively diving and presumably feeding within pan and brash ice (Bergman et al. 1977, Harrison 1977, Johnson and Richardson 1981, Sanger and Jones 1984). Johnson and Richardson (1981) collected four Oldsquaw feeding among ice floes 300 m from shore, and found that their stomachs contained large numbers of the ice-associated invertebrate, Apherusa glacialis. Scoters, in contrast, are much more restricted in their diet, eating primarily bivalves in both winter (Sanger and Jones 1984, at Kachemak Bay in Alaska) and summer (Vermeer and Bourne 1984, on the British Columbia coastline; Stott and Olson 1973, in New Hampshire). Thus, Oldsquaw may be better able than scoters to adapt to the environmental changes caused by the ice in McKinley and Hutchison bays.

A factor that affects the accuracy of the count during an aerial survey is the tendency for the ducks to aggregate into large flocks.

Large flocks of birds are more visible on aerial surveys than small groups, especially when conditions are less than favourable (Stott and Olson 1972). Savard (1982) also studied variability of waterfowl aerial surveys and found that differences in estimates were larger for species that aggregated into flocks than for species with a more scattered distribution. According to Gaston and Smith (1984), as flock sizes increase, survey intensity must also increase to obtain the same level of accuracy. During all years of our study, it was evident that scoters were frequently observed in large flocks, often over 100 birds and occasionally over 500 birds in one group. In contrast, Oldsquaw were less often found in large flocks. Thus, our population estimates were likely more accurate for Oldsquaw than for scoters.

Few eiders were observed during the five years of aerial surveys at McKinley and Hutchison bays. The female eiders observed during ground surveys, between July 24 and August 10 in 1982 were probably failed-nesting birds that were staging or resting during moult migration. According to Barry (1983), most of the eiders in the Beaufort Sea area probably moult in the Chukchi Sea.

Certain trends were evident in the distribution of diving ducks observed over the five years. At McKinley Bay, concentrations of both Oldsquaw and scoters were consistently seen near Atkinson Point, while the south end of the bay was used heavily by scoters. At Hutchison Bay, major concentrations of scoters were frequently observed in the north-east corner of the bay, while again, both Oldsquaw and scoters commonly utilized the areas just south of Warren Point. In general, Oldsquaw

were more evenly distributed than scoters. Oldsquaw were less frequently seen in huge concentrations, and tended to utilize more areas of both bays than did scoters.

The distribution of a population of moulting diving ducks at any time likely depends on the physical parameters of the environment which affect the abundance and distribution of the divers' food supply, the availability of suitable loafing places, and the provision of physical protection from wind and waves.

Food availability helps to determine the areas that waterfowl selectively use. Feeding studies at Simpson Lagoon found that Oldsquaw fed more often and most effectively in areas with higher densities of prey organisms (Johnson 1984). There is little information on either the abundance or the distribution of invertebrate organisms in McKinley Bay. However, the physical features of McKinley Bay suggest that accumulation of food organisms would be greatest in the south end of the bay and behind the spit at Atkinson Point (Herlinveaux, oceanographer, pers. comm.), which are the two areas of the bay where the highest duck densities occurred during our five-year study. Surface material, including phytoplankton, is transported into the bay by prevailing winds and accumulates at the south end. Invertebrate production is further enhanced by fine materials which also tend to accummulate in the south end of the bay, settling to the bottom, then entering the invertebrate food chain. The fine materials include dust transported by the wind, sediments transported by currents, and organic and inorganic material entering the bay from the stream at the south end. Nutrients are also

brought into the bay after tidal flooding of the lagoon south of the bay (T. Barry, pers. comm.).

The abundance of feed in the lee of Atkinson Point is probably a result of surface material moving eastward along the coast and moving around the point and then settling behind it (Herlinveaux, pers. comm.). Also, prevailing onshore winds blow across the Atkinson Point spit, resulting in wind-induced mixing along the leeshore side of the spit. Sub-surface materials, including nutrients, are brought to the surface, which may enhance the primary production of the area.

Barrier reefs and spits such as at Atkinson Point and Warren Point also provide physical protection from wind and waves to moulting diving ducks. Within Simpson Lagoon in Alaska, although densities of major prey species were significantly higher in the deeper (2.5 m) central portions of the lagoon, many Oldsquaw were observed closer to the lee sides of the islands, in slightly shallower water (Johnson and Richardson 1981). During our daily surveys in McKinley Bay in 1982, more birds used the area just south of Atkinson Point when winds were from the northwest or northeast than when winds were from the southeast (Cornish and Allen 1983). At McKinley Bay, a concentration of birds was frequently seen just south of the artificial island (Fig. 7), which would also give protection from the prevailing northwest winds. Other Beaufort Sea studies have likewise shown an association between wind direction and diving duck use of leeward sides of islands or barrier reefs (Johnson and Richardson 1981, LGL 1983, Vermeer and Anweiler 1975). The consistently high densities of observed divers on the

leeward sides of both Atkinson Point and Warren Point lend further support to the possibility that moulting diving ducks conserve energy by seeking shelter from the wind.

An analysis of the potential effects of development in McKinley Bay has already been carried out by Karasiuk and Boothroyd (1984). We feel that the quantitative information collected from this five-year study will allow objective interpretation of comparable post-development data, so that impacts of development on the numbers and distribution of diving ducks in McKinley Bay can be more accurately assessed. Our estimates of natural annual variation in numbers, however, must be accompanied by a better understanding of the specific biological processes that cause diving ducks to select these bays as moulting areas. It is especially recommended that studies of the food and feeding habits of these diving ducks in McKinley Bay be carried out, as it is suspected that an abundant food supply coupled with provision of physical protection from wind and waves are the two primary factors that direct the local abundance and distribution of divers in McKinley Bay.

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Appendix A. Scientific names of species of birds observed at McKinley Bay and Hutchison Bay during aerial surveys in 1985.

Appendix A. Scientific names of species of birds observed at McKinley Bay and Hutchison Bay during aerial surveys in 1985.

| Common name | Scientific name |
|---|---|
| Yellow-billed Loon | *Gavia adamsii* |
| Arctic Loon | *Gavia arctica* |
| Red-throated Loon | *Gavia stellata* |
| Tundra Swan | *Cygnus columbianus* |
| Brant | *Branta bernicla* |
| Greater White-fronted Goose | *Anser albifrons* |
| Lesser Snow Goose | *Chen caerulescens* |
| Northern Pintail | *Anas acuta* |
| American Wigeon | *Anas americana* |
| Scaup sp. | *Aythya* sp. |
| Common Eider | *Somateria mollissima* |
| King Eider | *S. spectabilis* |
| Oldsquaw | *Clangula hyemalis* |
| White-winged Scoter | *Melanitta fusca* |
| Surf Scoter | *Melanitta perspicillata* |
| Red-breasted Merganser | *Mergus serrator* |
| Northern Harrier | *Circus cyaneus* |
| Ptarmigan sp. | *Lagopus* sp. |
| Sandhill Crane | *Grus canadensis* |
| Phalarope sp. | *Phalaropus* sp. |
| Parasitic Jaeger | *Stercorarius parasiticus* |
| Glaucous Gull | *Larus hyperboreus* |
| Sabine's Gull | *Xema sabina* |
| Arctic Tern | *Sterna paradisaea* |
| Snowy Owl | *Nyctea scandiaca* |

Appendix B. Numbers of birds recorded on aerial transects at McKinley Bay on August 4, 1985.

Table B1. Birds observed on the marine component of aerial transects at McKinley Bay on August 4, 1985.

| Species | Transect number | | | | | | | | | | Total on all transects |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| Yellow-billed Loon | | 4 | | | | | | | | | 4 |
| Arctic Loon | | | | 3 | | | 1 | | | | 4 |
| Red-throated Loon | 4 | 2 | 6 | 6 | 8 | 3 | 4 | | | | 33 |
| Loon sp. | | 1 | | | 3 | | | | | | 4 |
| Tundra Swan | | | | | | | | | | | |
| Brant | | | | | | | | | | | |
| Greater White-fronted Goose | | | | | | | | | | | |
| Dark Goose | | | | 5 | | | | | | | 5 |
| Lesser Snow Goose | | | | | | | | | | | |
| Northern Pintail | 11 | 9 | | | 2 | 1 | | | | | 23 |
| American Wigeon | | | | | | | | | | | |
| Dabbling duck | | | | | | | | | | | |
| Eider sp. | | | | 1 | | | | | | | 1 |
| Scaup sp. | | 10 | 10 | 50 | | | | | | | 70 |
| Oldsquaw | 39 | 75 | 451 | 187 | 155 | 85 | 4 | | | | 996 |
| Scoter sp. | | 8 | 9 | 22 | 18 | 18 | | | | | 75 |
| White-winged Scoter | | | 1 | | 7 | | | | | | 8 |
| Surf Scoter | | 13 | 10 | 4 | 3 | 22 | 13 | | | | 65 |
| Red-breasted Merganser | | | | | | | | | | | |
| Diving duck | | | | 27 | | 13 | | | | | 43 |
| Unidentified duck | | 3 | | | 1 | | | | | | 4 |
| Raptor | | | | | | | | | | | |
| Ptarmigan sp. | | | | | | | | | | | |
| Sandhill Crane | | | | | | | | | | | |
| Shorebird | | 2 | | | | | | | | | 2 |
| Jaeger sp. | | | | | | | | | | | |
| Glaucous Gull | 1 | 3 | 3 | 2 | 1 | | 2 | | | | 12 |
| Sabine's Gull | | | | | | | | | | | |
| Arctic Tern | | | | | | | | | | | |
| Snowy Owl | | | | | | | | | | | |
| Passerine | | | | | | | | | | | |

Table B2. Birds observed on the terrestrial component of aerial transects at Mckinley Bay on August 4, 1985.

| Species | Transect number | | | | | | | | | | Total on all transects |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| Yellow-billed Loon | | | | | | | | | | | |
| Arctic Loon | | | | | 1 | | 1 | 3 | | | 5 |
| Red-throated Loon | | | | 2 | 4 | 6 | 8 | | 2 | 1 | 23 |
| Loon sp. | | | | 1 | 2 | | | | | | 3 |
| Tundra Swan | | | 6 | 9 | 3 | 3 | 24 | 4 | 3 | 9 | 61 |
| Brant | | | 30 | | | | | 8 | | | 38 |
| Greater White-fronted Goose | | | | | | | | | 31 | | 31 |
| Dark Goose | | | | 10 | | | 35 | 15 | | | 60 |
| Lesser Snow Goose | | | | | | | | | | | |
| Northern Pintail | | | | 13 | 10 | 5 | 47 | 12 | 36 | 12 | 135 |
| American Wigeon | | | | | 2 | | | | 13 | | 15 |
| Dabbling duck | | | | | 3 | 2 | 8 | | | | 13 |
| Eider sp. | | | | | | | | | | | |
| Scaup sp. | | | | | 3 | 14 | | | | | 17 |
| Oldsquaw | | | 2 | | 31 | 53 | 4 | 6 | | | 96 |
| Scoter sp. | | | | | | 20 | | | | | 20 |
| White-winged Scoter | | | | | | | | | | | |
| Surf Scoter | | | | | | | | | | | |
| Red-breasted Merganser | | | | | | | | 6 | 40 | | 46 |
| Diving duck | | | | | | 14 | | | | | 14 |
| Unidentified duck | | | | | 70 | | 20 | | 3 | 6 | 99 |
| Raptor | | | | | | | | | | | |
| Ptarmigan sp. | | | | | | 1 | | | | | 1 |
| Sandhill Crane | | | | 1 | 1 | | 3 | | | | 5 |
| Shorebird | | | | | 13 | | 32 | 9 | | | 54 |
| Jaeger sp. | | | | | | | 1 | | | 1 | 2 |
| Glaucous Gull | | | 1 | 1 | 1 | 6 | 6 | 8 | 1 | | 24 |
| Sabine's Gull | | | | | | | | 17 | | | 17 |
| Arctic Tern | | | | | 8 | | | | | | 8 |
| Snowy Owl | | | | | | | | | | | |
| Passerine | | | | | 20 | | 2 | | | | 22 |

Table B3. Birds observed on the outside component of aerial transects at Mckinley Bay on August 4, 1985.

| Species | Transect number | | | | | | | | | | Total on all transects |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| Yellow-billed Loon | | | | | | | | | | | |
| Arctic Loon | | | | | | | | | | | |
| Red-throated Loon | | | 1 | 3 | 7 | | | | | | 11 |
| Loon sp. | | | | | | | | | | | |
| Tundra Swan | | | | | | | | | | | |
| Brant | | | | | | | | | | | |
| Greater White-fronted Goose | | | | | | | | | | | |
| Dark Goose | | | | | | | | | | | |
| Lesser Snow Goose | | | | | | | | | | | |
| Northern Pintaill | | | | | | | | | | | |
| American Wigeon | | | | | | | | | | | |
| Dabbling duck | | | | | | | | | | | |
| Eider sp. | | | | | | | | | | | |
| Scaup sp. | | | | | | | | | | | |
| Oldsquaw | | | | | | | | | | | |
| Scoter sp. | | | | | | | | | | | |
| White-winged Scoter | | | | | | | | | | | |
| Surf Scoter | | 2 | | | | | | | | | 2 |
| Red-breasted Merganser | | | | | | | | | | | |
| Diving duck | | | | | | | | | | | |
| Unidentified duck | | | | | | | | | | | |
| Raptor | | | | | | | | | | | |
| Ptarmigan sp. | | | | | | | | | | | |
| Sandhill Crane | | | | | | | | | | | |
| Shorebird | | | | | | | | | | | |
| Jaeger sp. | | | | | | | | | | | |
| Glaucous Gull | 1 | | 1 | 1 | | 1 | | | | | 4 |
| Sabine's Gull | | | | | | | | | | | |
| Arctic Tern | | | | | | 1 | | | | | 1 |
| Snowy Owl | | | | | | | | | | | |
| Passerine | | | | | | | | | | | |

Appendix C. Numbers of birds recorded on aerial transects at Hutchison Bay on August 4, 1985.

Table C1. Birds observed on the marine component of aerial transects at Hutchison Bay on August 4, 1985.

| Species | Transect number | | | | | | | Total on all transects |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Yellow-billed Loon | | | | | | | | |
| Arctic Loon | | 2 | | | 1 | | | 3 |
| Red-throated Loon | | 9 | 2 | 3 | 4 | | | 18 |
| Loon sp. | 1 | | | | | | | 1 |
| Tundra Swan | | | | | | | | |
| Brant | | | | | 25 | | | 25 |
| Greater White-fronted Goose | | | | | | | | |
| Dark Goose | | | | | | | | |
| Lesser Snow Goose | | | | | 24 | | | 24 |
| Northern Pintail | | | | | | | | |
| American Wigeon | | | | | | | | |
| Dabbling duck | | | | | | | | |
| Eider sp. | 2 | 4 | 2 | 1 | 2 | | | 11 |
| Scaup sp. | 10 | 4 | 78 | 10 | | | | 102 |
| Oldsquaw | 256 | 120 | 361 | 57 | 78 | | | 872 |
| Scoter sp. | 50 | 70 | 123 | 5 | 30 | | | 278 |
| White-winged Scoter | 8 | 8 | 38 | 10 | | | | 64 |
| Surf Scoter | 12 | 400 | | 8 | 23 | | | 443 |
| Red-breasted Merganser | | 2 | 4 | | | | | 6 |
| Diving duck | | 3 | | 22 | | | | 25 |
| Unidentified duck | | | 28 | | | | | 28 |
| Raptor | | | | | | | | |
| Ptarmigan sp. | | | | | | | | |
| Sandhill Crane | | | | | | | | |
| Shorebird | | | | | | | | |
| Jaeger sp. | | | | | | | | |
| Glaucous Gull | 5 | 5 | 11 | | | | | 21 |
| Sabine's Gull | | | | | | | | |
| Arctic Tern | | | | 1 | | | | 1 |
| Snowy Owl | | | | | | | | |
| Passerine | | | | | | | | |

Table C2. Birds observed on the terrestrial component of aerial transects at Hutchison Bay on August 4, 1985.

| Species | Transect number | | | | | | | Total on all transects |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Yellow-billed Loon | | | | | | | | |
| Arctic Loon | | | | 4 | 4 | 3 | 8 | 19 |
| Red-throated Loon | | 2 | | | 7 | 5 | 19 | 33 |
| Loon sp. | | | | 7 | 4 | 1 | 5 | 17 |
| Tundra Swan | | | | 9 | 4 | 12 | 23 | 48 |
| Brant | | | | 40 | | | | 40 |
| Greater White-fronted Goose | | | | | | 25 | 6 | 31 |
| Dark Goose | | | | | | 25 | | 25 |
| Lesser Snow Goose | | | | | | | | |
| Northern Pintail | | | | 44 | 3 | 223 | 3 | 273 |
| American Wigeon | | | | 5 | | | | 5 |
| Dabbling duck | | | | 21 | 35 | 3 | | 59 |
| Eider sp. | | | | | | | | |
| Scaup sp. | | | | | | 12 | | 12 |
| Oldsquaw | | 12 | | | 2 | | 12 | 26 |
| Scoter sp. | | | | | | | | |
| White-winged Scoter | | 20 | | | | | | 20 |
| Surf Scoter | | | | | | | | |
| Red-breasted Merganser | | | | | | | 30 | 30 |
| Diving duck | | | | | | | | |
| Unidentified duck | | | | | | | | |
| Raptor | | | | | | | 1 | 1 |
| Ptarmigan sp. | | | | | | 7 | | 7 |
| Sandhill Crane | | | | | | | | |
| Shorebird | | 15 | | 39 | 21 | 3 | 4 | 82 |
| Jaeger sp. | | | | | | | | |
| Glaucous Gull | | 7 | | 4 | 12 | 1 | 11 | 35 |
| Sabine's Gull | | | | | | | | |
| Arctic Tern | | 3 | | | | | 7 | 10 |
| Snowy Owl | | | | | | | | |
| Passerine | | | | | | | | |

Table C3. Birds observed on the outside component of aerial transects at Hutchison Bay on August 4, 1985.

| Species | Transect number | | | | | | | Total on all transects |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Yellow-billed Loon | | | | | | | | |
| Arctic Loon | | | | | | | | |
| Red-throated Loon | | 3 | | | | | | 3 |
| Loon sp. | | | | | | | | |
| Tundra Swan | | | | | | | | |
| Brant | | | | | | | | |
| Greater White-fronted Goose | | | | | | | | |
| Dark Goose | | | | | | | | |
| Lesser Snow Goose | | | | | | | | |
| Northern Pintail | | | | | | | | |
| American Wigeon | | | | | | | | |
| Dabbling duck | | | | | | | | |
| Eider sp. | 9 | 1 | | | | | | 10 |
| Scaup sp. | | | | | | | | |
| Oldsquaw | | 25 | | | | | | 25 |
| Scoter sp. | | | | | | | | |
| White-winged Scoter | | | | | | | | |
| Surf Scoter | | | | | | | | |
| Red-breasted Merganser | | | | | | | | |
| Diving duck | | | | | | | | |
| Unidentified duck | | | | | | | | |
| Raptor | | | | | | | | |
| Ptarmigan sp. | | | | | | | | |
| Sandhill Crane | | | | | | | | |
| Shorebird | | | | | | | | |
| Jaeger sp. | | | | | | | | |
| Glaucous Gull | 9 | 5 | | | | | | 14 |
| Sabine's Gull | | | | | | | | |
| Arctic Tern | 7 | 2 | | | | | | 9 |
| Snowy Owl | | | | | | | | |
| Passerine | | | | | | | | |

Appendix D. Summary of industrial activity within McKinley Bay in the 1984-85 season.

Appendix D. Summary of industrial activity within McKinley Bay in the 1984-85 season.

Fewer vessels were anchored in McKinley Bay in the winter of 1984-85 than in previous years (J. Ward, pers. comm.). A total of 13 ships belonging to the Canmar drilling fleet, including drillships, associated supply vessels and one icebreaker, were overwintered in McKinley Bay in 1984-85. Other vessels that overwintered in the bay were a drydock with its support barge, the Single Steel Drilling Caisson, the Canmar Shuttle fuel barge and several smaller barges. The ships departed the bay in early August 1985, later than usual because of difficult ice conditions. Activities associated with the operation of the harbour in the 1985 summer months involved vessel traffic within the bay and aircraft traffic to and from the bay, including a Twin Otter scheduled one daily as well as helicopter flights. Both aircraft and vessel traffic decreased after the ships left the bay in early August.

Appendix E. Results of a Kruskal-Wallis test to determine whether diving duck densities differed significantly between the years 1981 and 1985 at McKinley Bay or Hutchison Bay.

Appendix E. Results of a Kruskal-Wallis test to determine whether diving duck densities differed significantly between the years 1981 and 1985 at McKinley Bay or Hutchison Bay.

| | McKinley Bay | | Hutchison Bay | |
|---|---|---|---|---|
| Species | T* | p** | T | p |
| Oldsquaw | 2.48 | $p>0.60$ | 11.78 | $p<0.01$ |
| Scoter sp. | 7.84 | $p<0.10$ | 0.90 | $p>0.75$ |
| Total divers*** | 10.24 | $p<0.05$ | 7.27 | $p<0.10$ |

*T = the test statistic, calculated from the ranks assigned to each density observation (Conover 1980).

**Null hypothesis of no variation between years in the density of each diving duck species was accepted if $p \geq 0.10$.

***Includes to all species of diving ducks.